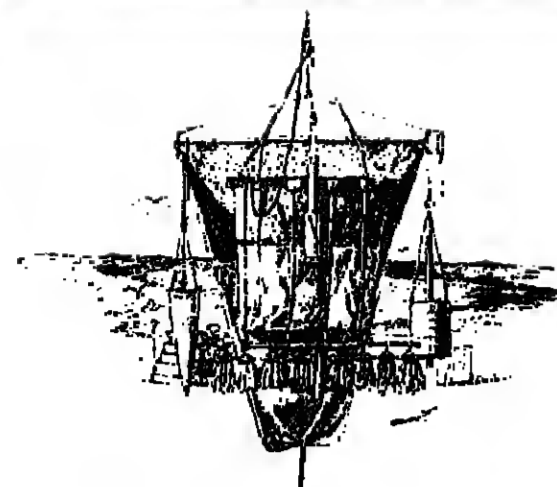


The Oceanography Report



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The Oceanography Report

The focal point for physical, chemical, geological, and biological oceanographers.

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A Synopsis of PROBES

J. J. Goering and C. P. McRoy

Introduction

The Processes and Resources of the Bering Sea Shelf (PROBES) project is a 6-year multi-institutional (University of Alaska, Florida State University, University of Washington, Brookhaven National Laboratory, Southwest Fisheries Center, Bigelow Laboratory for Ocean Sciences) interdisciplinary study designed to understand the processes that contribute to the production of enormous numbers of animals (including crabs, fish, birds, mammals) in secondary and higher trophic levels in the vast Bering Sea continental shelf. The research plan is based on the hypothesis that the broad shallow shelf leads to an oceanographic structure of a semi-permanent front-interfront system in which phytoplankton primary production is coupled to a pelagic food web over the outer shelf and to a benthic food web in the middle shelf (see cover, this issue). The project has concentrated on the processes that control the survival of the early life history stages of the Alaska pollock (*Theragra chalcogramma* Pallas) as an example of mass and energy transfer in the pelagic system. PROBES began in 1976 and is sponsored by the Division of Polar Programs, National Science Foundation.

PROBES is organized into five major components of research: (1) water circulation and mixing, (2) nutrient dynamics, (3) primary productivity and phytoplankton ecology, (4) upper trophic-level ecology, and (5) ecosystem analysis and synthesis.

The justification and need for PROBES is derived from national and international interests in science and economics. The Bering Sea is the third largest sea in the world, exceeded only by the Mediterranean and South China seas. About 45% of its area is continental shelf constituting the largest American coastal sea and containing immense quantities of renewable and nonrenewable resources. The yearly economic value of its fishery resources (~5% of the total annual world catch) is several hundred million dollars.

The U.S. fishing activities have been confined largely to king and tanner crabs and salmon, while for many years the foreign fishing fleets of Japan, Korea, and the Soviet Union have extensively exploited stocks of various fish species (e.g., Alaska pollock, yellowfin sole). This sea plays a major role in supplying marine protein to many nations and also has many basins with excellent petroleum potential, and extensive petroleum exploration is in the planning process. The results of PROBES will be valuable in providing an ecological basis for management aspects of the resources of this and other high latitude continental shelves. The growing awareness of the importance of oceanic fronts in regulating oceanic productivity and chemistry, and in concentrating food and animals at all trophic levels in food webs, is additional justification for studies such as PROBES.

We attribute the success of PROBES as a multi-disciplinary team study to the strong central hypothesis that was formulated and revised with information made available from the collective efforts of all PROBES investigators. The present hypothesis is substantially different from our initial understanding of how this shelf ecosystem functions. The results of early PROBES and the Bureau of Land Management/National Oceanic and Atmospheric Administration sponsored Alaska Outer Continental Shelf Environment Assessment Program field work revealed a very different pattern of ecosystem structure and function from that initially hypothesized. In the following sections we summarize PROBES results that support the general hypothesis that major pelagic and benthic food webs leading to large stocks of animals are separated in space and are organized in relation to the three oceanic fronts that exist in the southeastern Bering Sea.

Water Circulation and Mixing in the Southeastern Bering Sea

Three fronts separate the waters overlying the southeastern Bering Sea shelf into three distinct hydrographic domains (see cover, this issue). Each domain has distinct temperature, salinity, and stratification properties, and each has different circulation features (Coachman et al., 1980). The shelf break front is within ± 50 km of the shelf break (~170 m isobath), about 500 km from shore; the middle front lies over the 80 to 100-m isobaths, 350–400 km from shore; and the inner front is centered over the 50-m isobath, 80–150 km from shore. Proceeding landward from the shelf break front the hydrographic domains are called outer, middle, and coastal.

Fronts are regions of convergence in the horizontal transport (flux) of water properties in the direction normal to the front, over the water column depth encompassed by the front. On the shelf of the Bering Sea, salt is essentially conserved in both time and space, and salinity can be used to describe the fronts. Other properties such as temperature, nutrients, and biological materials (e.g., chlorophyll) frequently depict the fronts. The fronts also border changes in vertical water column structure.

The broad shelf break front (~50 km wide) extends along the shelf edge from Unimak Island to Cape Navarin. It designates the outer boundary of a less saline shelf water converging with oceanic water. An enhanced mean salinity gradient of $(\Delta S/\Delta X) \sim 10 \times 10^{-3} \text{ g kg}^{-1} \text{ km}^{-1}$ increasing seaward and extending down from the surface over the upper two-thirds of the water column delineates this front. The actual orientation of the convergence zone is not vertical but slopes from the surface landward at ~ 1.5 to 2 m/km. A similar enhanced horizontal gradient of mean salinity and temperature in the bottom one third to one half of the water column describes the middle front and also marks a transition

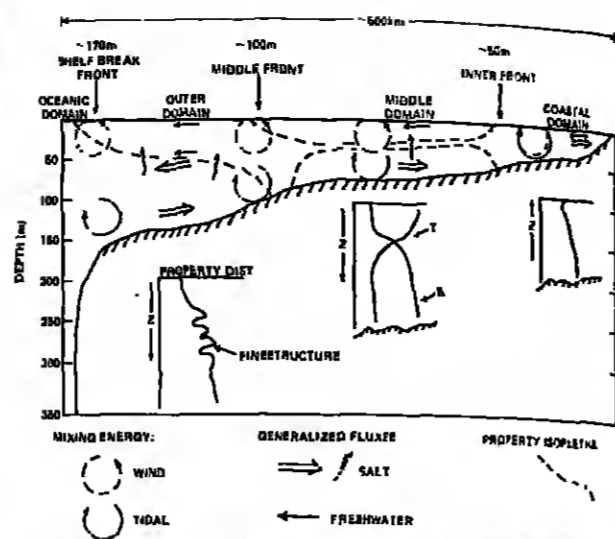


Fig. 1. A schematic diagram of the mixing energy balance in the different domains and associated water column structures. Note the correlation of the fronts with regions of greater bottom slope. Also indicated are generalized isopycnal distributions and salt and freshwater fluxes [from Coachman et al., 1980].

tion in vertical water column structure (Figure 1). Landward of this front the middle domain is two-layered, while seaward the upper and lower relatively mixed layers are separated by a third layer replete with fine structures. The 15 to 20-km wide inner front is also a region of change in water column structure, from two layers in the middle domain to vertically well mixed in the coastal domain. The inner front has mean horizontal salinity gradients of $\sim 2 \times 10^{-3} \text{ g kg}^{-1} \text{ km}^{-1}$ and is also layered, the gradients being more strongly developed in the lower half of the water column. Horizontal salinity gradients are low ($\sim 1 \times 10^{-3} \text{ g kg}^{-1} \text{ km}^{-1}$) across the middle domain, while in the coastal domain gradients are an order larger ($\sim 10 \times 10^{-3} \text{ g kg}^{-1} \text{ km}^{-1}$).

The Bering Sea shelf break front is analogous with other extensively studied mid-latitude shelf edge fronts such as those of the mid-Atlantic Bight and Nove Sciole. The inner front appears characteristic of the shelf fronts described around the British Isles, while the middle front may have counterparts in other very broad mid-latitude seas (e.g., North Sea, East China Sea).

The circulation on the southeastern Bering Sea shelf is tidally dominated. Extensive moored current meter and satellite drifter observations indicate scatter mean tidal speeds of ~ 20 to 25 cm/s , increasing shoreward, and most of the horizontal kinetic energy is at tidal frequencies, varying from 60% over the outer shelf to >90% in the coastal domain. Subtidal flow is weak ($1\text{--}5 \text{ cm/s}$) and parallel to the fronts in the vicinity of the shelf break and inner fronts, while flow in the middle domain is insignificant. No evidence exists for mass or momentum exchange between this shelf and adjacent oceanic waters by eddies or current rings. Because some freshwater is continually added by land runoff while the long-term salinity field is essentially constant, on-off shelf fluxes of freshwater and salt are continuous and primarily tidally driven. A hypothesis explaining the Bering Sea shelf fronts based on the conservation of salt is discussed by Coachman et al. (1980).

Coachman et al. (1980) have described the mixing energy balance and the associated water column structure on the southeastern Bering Sea shelf. The inner and middle fronts are formed where vertical fluxes of water properties are enhanced by physical conditions concomitant with a basic change in water column structure. Structural change is from one to two layers at the inner front and from two to three at the middle front. The changes occur where the bottom depth exceeds the depths of balance between tidal mixing energies from the bottom up against buoyancy and wind stirring downward from above. As these energies are approximately constant over the shelf the thickness of the layers containing tidal and wind mixing energies is also about constant, thus where depth changes the structural layering of the water column also changes. These conditions, together with generalized vertical property distributions and fluxes on the southeastern Bering Sea shelf, are summarized schematically in Figure 1.

Upwelling in the middle and inner fronts is a consequence of flow convergence. In the middle front, convergence is primarily due to a landward subtidal flow beneath 30 m of $\sim 2\text{--}3 \text{ cm/s}$ across the outer domain. This onshore-offshore subtidal flow is variable over 1–5 day periods, and hence the intensity of convergence appears to be directly correlated to atmospheric events. This convergence results in average upwelling of $\sim 10^{-3} \text{ cm/s}$. Continuity is preserved by dispersion in the surface layer. The inner front conditions appear to be similar to those of the middle front. There is also upwelling at this front, and mass redistribution drives a small baroclinic current to the north parallel to the front which assists in maintaining continuity.

Role of Fronts in Southeastern Bering Sea Food Webs

Information relative to the effects of frontal zones on phytoplankton and zooplankton production, species composition, and community structure of high latitude shelves is sparse, but it is clear that frontal zones are often regions where biological productivity is much greater than that of the water mass on either side of the front. PROBES is studying the processes that maintain high primary productivity in shelf frontal zones as well as the mechanisms that lead to the transfer of mass and energy from primary producers to and between consumers.

In the shelf domain of the southeastern Bering Sea the patterns of phytoplankton and zooplankton growth, biomass, and species composition are organized in relation to

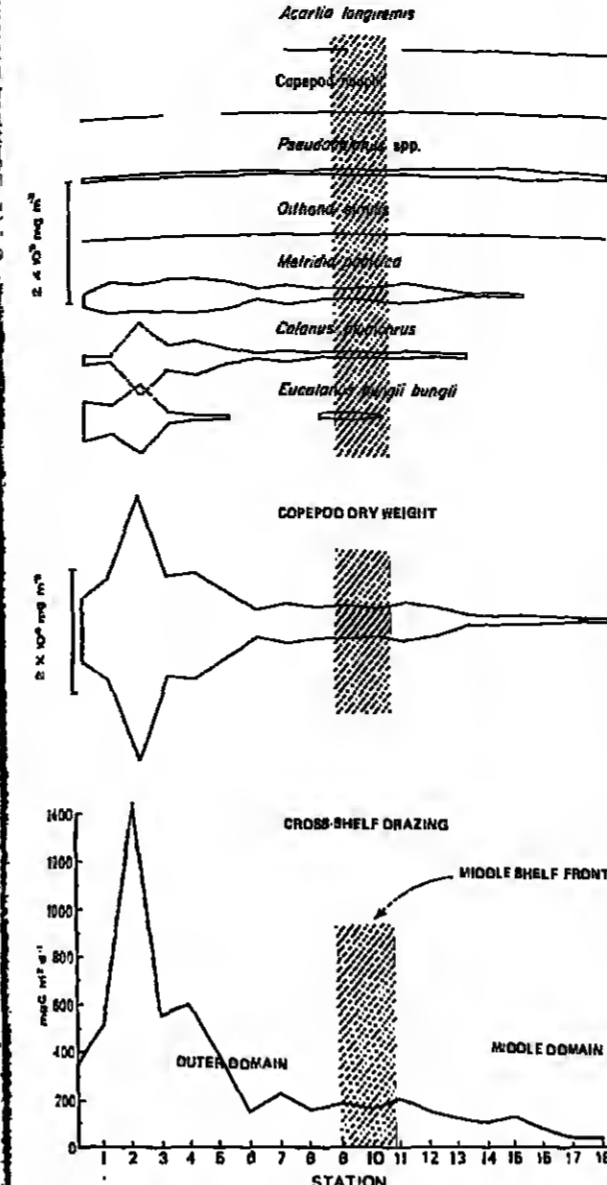


Fig. 2. Southeastern Bering Sea cross-shelf measured copepod grazing, dry weight, and species distributions (May 1979). Note position of middle front (modified from Cooney and Coyle [1981]).

the three fronts. Enhanced biological activity takes place preferentially within the surface layer near frontal zones; enhancement is particularly evident in the middle front where convergence of oceanic-derived materials and nutrients in lower layers leads to property upwelling. The middle front also acts as a substantial barrier, markedly reducing the landward cross-shelf transport of plankton and other particles and dissolved materials. The focusing of materials along this front undoubtedly accounts for the notable enrichment of biological activity observed at this front [Iverson et al., 1980].

The sequence of spring phytoplankton events and species succession differs in the middle and outer shelf domains which are separated by the middle front. Light, nutrients, grazing, and vertical turbulence all influence the growth and structure of phytoplankton communities. Turbulence, in particular, assumes an important role in controlling initiation of the spring bloom. The bloom commences first in the middle and coastal domains; these are also areas of largest bloom development.

The time course of spring phytoplankton blooms in the middle domain has been observed for several years. Increases in vertically integrated chlorophyll concentration occur after breaks in the normal pattern of storm movement (several per week) through the southeastern Bering Sea. During the past 3 years, favorable periods of water column stabilization for bloom initiation have appeared in early May. The tails of the seasonal production cycle after bloom initiation is also largely determined by the vagaries of storm events and their effects on the wind mixed layer. Meteorological events thus play an important role in regulating the primary production cycle on the southeastern Bering Sea shelf, as well as influence the intensity of convergence at the middle front and reuplift of nutrients to the post bloom nutrient depleted euphotic layer.

The typical cold, northern high latitude seasonal phytoplankton successional sequence develops in the Bering Sea middle domain but not in the outer domain. In the outer domain much of the seasonal productivity ($\sim 200 \text{ g C m}^{-2} \text{ yr}^{-1}$) is associated with *Phaeocystis pouchetii*, a non-silicaceous haptophyte, whereas in the middle domain successional stages of diatoms are responsible for most of the productivity ($\sim 400 \text{ g C m}^{-2} \text{ yr}^{-1}$). The small sized diatoms of the genera *Thalassiosira* and *Chaetoceros* dominate stage I; medium sized diatoms of the genera *Chaetoceros*, *Corethron*, *Rhizosolenia*, and *Nitzschia* dominate stage II; and large long chained *Rhizosolenia alata*, which can grow under low nutrient conditions dominate stage III middle domain phytoplankton numbers. Evidence from grazing experiments suggests that most of the outer shelf diatom production is grazed by large North Pacific Interzonal species of calanoid copepods and euphausiids (e.g., *Calanus crassus*, *C. plumchrus*, *Eucalanus bungii*, *Eucalanus inermis*, and *Thysanoessa raschii*), which do not graze *Phaeocystis* [Cooney and Coyle, 1981]. The outer shelf domain phytoplankton community is held successively stable during spring by heavy grazing, which produces the observed low plant diversity and high dominance of *Phaeocystis*. The large herbivorous copepods and euphausiids of the outer shelf grazing community are restricted to the outer shelf domain by the physical constraints imposed by the middle front. Although small copepods (e.g., *Pseudocalanus* spp.,

Oithona similis, *Acartia longiremis*) are distributed across the whole shelf, the grazing stress on diatoms is lower in the middle domain than in the outer shelf domain.

The large outer shelf copepods have monocyclic life cycles with ontogenetic vertical migrations, in which growth and development of the copepod stages take place in surface waters, but reproduction occurs during winter in deep water off the shelf in the absence of food. Juvenile stages migrate to the surface before spring bloom initiation and begin grazing as the bloom develops. The smaller numerically dominant species of the middle shelf produce several broods per year only after local (phytoplankton) becomes abundant. Thus intense spring blooms of phytoplankton develop in the middle domain before extensive grazing begins, and grazing by these small species never harvests a large amount of the phytoplankton production. Thus underuse of phytoplankton results in significant transport of phytoplankton detritus to the seabed in the middle shelf.

The differential grazing stress imposed by the physical conditions that prevail on the southeastern Bering Sea shelf regulates the patterns of phytoplankton productivity and standing crop as well as partitions the shelf into two regions, one dominated by a pelagic food web (outer domain) and the other by a benthic food web (middle domain). The outer shelf domain is characterized by lower standing stocks of phytoplankton and by absence of a well-defined spring bloom. The large herbivorous grazers continually harvest a major portion of the primary production in the outer shelf domain, and this leads to a predominantly pelagic food web in this region of the shelf. However, in the middle shelf, substantial amounts of primary production are harvested by the smaller copepods, and much of it is available to benthic-type food webs. The differences between domains in the levels of primary productivity and grazing result in over 3 times more phytoplankton remaining ungrazed in the middle domain than in the outer. The consequences of this cross-shelf pattern of productivity and grazing are also evident in upper trophic levels. The extensive pelagic fisheries of the Bering Sea are concentrated in the shelf break front and outer domain while the benthic related species (such as king crab and yellowfin sole) predominate in the middle shelf.

Summary

PROBES is a multi-institutional, interdisciplinary study of the marine ecosystem of the southeastern Bering Sea. The major effort of the program is to understand the processes that contribute to the large production of animals in various trophic levels. The waters over this shelf are highly structured and consist of discrete domains divided by three distinct oceanic fronts. PROBES is examining the importance of these fronts in regulating production of plants and animals and has discovered that these fronts are zones of enhanced biological activity and that the patterns of phytoplankton and zooplankton growth, biomass, and species composition are organized in relation to the fronts. The middle front, in particular, is a zone of enhanced biological activity, and it separates the middle shelf benthic dominated food web region from the outer shelf pelagic food web dominated region.

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Information Report

IUCRM Symposium

The 8th Inter-Union Commission on Radio Meteorology (IUCRM) symposium was held on May 13–20, 1981, in Miami Beach, Florida. The topic of the symposium was "Wave and Beam Propagation in the Ionosphere." The National Oceanic and Atmospheric Administration (NOAA), the National Science Foundation, and the Office of Naval Research (ONR) participated in the organization.

The purpose of the symposium was to review in depth the theoretical, experimental, and observational developments of the past few years and the presentation of new results in basic wave dynamics, of wind-wave research results in basic wave dynamics, of wind-wave spectra, and interactions with oceanic structures, measurements, and analysis techniques including microwave, HF methods, and classical methods, "inverse" modeling, wave prediction, and related topics such as oceanic turbulence and upper ocean layer dynamics.

The program/organizing committee consisted of Sir George Deacon, Institute of Oceanographic Sciences, Wormley, Godalming, Surrey, U.K., honorary chairman; W. M. Phillips, Department of Earth and Planetary Sciences, The Johns Hopkins University, Baltimore, Md., and Klaus Hasselmann, Max-Planck-Institut für Meteorologie, Hamburg, Fed. Rep. of Germany, co-chairman; Donald E. Bortick, NOAA Environmental Research Laboratory, Boulder, Colo.; Acad. L. M. Brekhovskikh, Institute of Oceanology, Moscow, USSR; Fred W. Dobson, Bedford Institute of Oceanography, Dartmouth, Canada; Norden E. Huang, NASA Wallops Flight Center, Wallops Island, Va.; Robert B. Long, NOAA Atlantic Oceanographic & Meteorological Laboratories, Miami, Fla.; Co-chairmen of local arrangements; M. S. Longuet-Higgins, University of Cambridge, Cambridge, U.K.; V. H. Munk, Scripps Institution of Oceanography, La Jolla, Calif.; Duncan B. Ross, NOAA/AOML, Miami, Fla., chairman of local arrangements; Y. Toba, Geophysical Institute, Tohoku University, Sendai, Japan; G. R. Velenzuela, Naval Research Laboratory, Washington, D.C.; secretary; Sture Wicker, National Defense Research Institute, Stockholm, Sweden, chairman of IUCRM.

This IUCRM symposium, in contrast to previous ones (except for the one in Venice, Italy last year), was open and attended by 181 (the estimated count was closer to 200) registered scientists and other observers; two-thirds were from the United States. The attendance included oceanographers, meteorologists, geophysicists, and about one-third radio scientists from 15 countries (i.e., Australia, Canada, Peoples Rep. of China, Denmark, France, Fed. Rep. of Germany, Ireland, Italy, Japan, Mexico, The Netherlands, Norway, United Kingdom, United States, and USSR).

The opening ceremonies of May 13 included introductory remarks by Sir George Deacon and key note addresses by Herbert Rabin (Deputy Assistant Secretary of the U.S. Navy), William Rensby (Deputy Administrator for Science and Applications of NASA), and Ferris Webster (Assistant Administrator for Research and Development of NOAA). The technical program included 6 review papers, 61 research contributions, one open workshop, and 30 poster papers. The proceedings of the symposium including comments and discussions during the presentations will be published by Plenum Press in book form with K. Hasselmann and O. M. Phillips serving as editors.

Overall, this IUCRM Symposium was a great success, helping to bring together once more oceanographers and radio scientists on the one hand and theoreticians and experimentalists on the other. One of the main outputs of this meeting was the acknowledgment that microwave remote sensing techniques from satellite, aircraft, towers, coastal plans, and in the laboratory offer a new dimension to measurements of the air-sea-water interface. In not resili, these techniques are becoming widely accepted by oceanographers and geophysicists, and a number of them are planning to use these instruments in the near future. We should thank our former colleague, the late John W. Wright from the Naval Research Laboratory, for his state of affairs, since he was one of the pioneers in radio-oceanography and made important contributions to remote sensing and oceanography. As a matter of fact, his name was often quoted throughout this meeting.

The main interests in the field now are in the nonlinear processes of the surface wave field, the directional spectrum of ocean waves, and in the validation/improvement of wave prediction models. Some specific highlights of the symposium are given below. Theoretical and experimental evidence (wave tanks) was given of strong nonlinear interactions of water waves that lead to subharmonic instability, wave breaking, group splitting, crest piling, etc. For ocean waves, the experimental evidence continues to support the concept of weakly interacting free waves with a unique dispersion relation, and nonlinear effects amount to no more than about 10%. The directional spectrum of ocean waves may be obtained from aircraft with single- and dual-frequency short-pulsed microwave radars and with ground-based HF systems. The microwave ellimeter from aircraft and satellite is able to profile ocean waves with high precision, but nonlinearities of waves can introduce a bias in the mean ocean level as large as 80 cm. The SEASAT SAR yields the wavelength of ocean waves within $12 \pm 7\%$ and wave direction within $12^\circ\text{--}15^\circ$. Longuet-Higgins presented a real breakthrough in analytical modeling of the "overturning" fluid in plunging, breaking waves. Breaking waves contribute an unusually large amount of backscatter to microwave remote sensors. Coherent microwave radars may be the ideal instrument for investigating the elusive process of wave breaking. HF techniques are capable of determining a number of parameters of dekameter ocean waves, including near surface ocean currents. Theoretical and experimental investigations were presented on the generation of land waves, the coupling of short waves with long gravity waves, and on the wave-induced flow in the air. The statistics of zero crossings and other parameters of wind waves were investigated in a wave tank, and they were in qualitative agreement with Longuet-Higgins' earlier predictions. NOAA's Coastal Wave Program was reviewed, together with remote sensing experiments such as ARSLOE. A future experiment to delineate the processes that lead to surface expressions of bathymetry in the wave field and radar images is being organized (SEBEX). Mesoscale turbulence processes were discussed in regard to wind measurements from radar backscatter. The symposium closed with an open workshop on Wave-Model Intercomparison, organized by K. Hasselmann. The objective was to test the numerical end physics of a number of wave prediction models that use discrete spectral, parametric, and parametric/hybrid techniques. These wave prediction models were applied to six prediction tests: limited fetch and duration, slanting fetch, windy half-plane, diagonal front, and stationary and moving hurricane. For single prediction situations, all wave models behaved in similar fashion, after the numericals had been corrected, and the quality of the prediction depended mostly on the accuracy of the wind field used. However, for extreme situations such as hurricane conditions, a wide spread of answers resulted. For stationary hurricanes, the significant wave height varied from 10 to 25 m and for moving hurricanes the spread was 10 to

Nominations are invited for

1982 Rosenstiel Award in Oceanographic Science

This award, which is administered on behalf of the Rosenstiel School of Marine and Atmospheric Science (RSMAS), University of Miami, recognizes outstanding contributions to marine science, including oceanographically relevant aspects of atmospheric science, and fundamental developments in ocean engineering. The award consists of a cash prize, currently \$5,000, and a medal. The recipient of the award will be invited to spend a week at RSMAS for discussions with faculty and students. The award will be presented at a banquet at that time.

To accommodate the multidisciplinary value of oceanographic science, the award recognizes, on a rotating basis, achievements in four broad disciplinary areas. In 1982 the emphasized discipline will be marine geology and geophysics. The achievements recognized may consist of contributions towards the development of ocean science in general, or of more focused individual research or recognized impact on our understanding of the marine environment.

Nominations for the 1982 award for outstanding achievement in marine geology and geophysics should be directed to the Interim Dean, Warren J. Wisby, Rosenstiel School of Marine and Atmospheric Science, University of Miami, 4600 Rickenbacker Causeway, Miami, Florida 33149, before March 15, 1982. Nominations should include a brief justification together with relevant references, and a c.v. if possible. The selection panel would especially welcome nominations of outstanding younger scientists whose early contributions suggest a continued role of leadership in the field.

Previous recipients of the award in Marine Geology and Geophysics have been Edward Ringwood, Kenneth Emery, and John Slater.

20 m. Presently, it is not possible to assess which of these predictions is correct since there is no complete data set on extreme conditions. The result is that further tests are warranted with these models, and additional data on hurricane conditions are urgently needed.

The Program/Organizing Committee is most grateful for the generous financial support of NASA, NOAA, and ONR and would like to commend the efforts of the Local Arrangements Committee composed of Duncan Ross, Bob Long, their wives and the American Meteorological Society.

G. R. Velenzuela is with the Environmental Sciences Division, Naval Research Laboratory, Washington, D.C.

News and Announcements

JGR on the South Atlantic Bight

A special issue of the *Journal of Geophysical Research* will be devoted to scientific results from studies of physical processes in the southeast U.S. continental shelf and adjacent Gulf Stream waters. Individuals who have worked in this area, especially in regard to Gulf Stream meanders and eddies, interaction with shelf water, topographic influences, wind influences, and shelf circulation, are encouraged to submit manuscripts for this issue.

To aid in planning this issue, please inform Thomas N. Lee, School of Marine and Atmospheric Science, University of Miami, 4600 Rickenbacker Causeway, Miami, Florida 33149 (telephone: 305-350-7491) of the tentative title of your manuscript and author by December 1, 1981. Manuscripts should be submitted in quadruplicate before April 1, 1982, to A. D. Kirwan, Jr., Editor, JGR, Department of Marine Science, University of South Florida, 140 Seventh Avenue South, St. Petersburg, Florida 33701. Standard JGR review procedures will be followed.

Adopted: A Practical Salinity Scale

The Unesco/ICES/SCOR/IASO Joint Panel on Oceanographic Tables and Standards has recommended the adoption of a Practical Salinity Scale, 1978, and a corresponding new international equation of state of seawater, 1980. A full account of the research leading to their recommendation is available in the series *Unesco Technical Papers in Marine Science*.

The parent organizations have accepted the panel's recommendations and have set January 1, 1982, as the date when the new procedures, formulas, and tables should replace those now in use.

So far as users are concerned, little is needed except the use of the new International Oceanographic Tables or equations. These, together with an explanatory introduction, will be made available by the Unesco Division of Marine Sciences as soon as possible.

All oceanographers are urged to use the new tables or equations for work reported on and after January 1, 1982. They should note in particular that the use of the new International Equation of State of Seawater, 1980, requires the use of salinity values determined on the Practical Salinity Scale, 1978. To avoid confusion, authors and editors are particularly requested to ensure that during the period of change, published values are accompanied by an indication as to which tables or equations have been used in their determination.

Oceanography Luncheon

A reminder: There is a limited number of tickets for this Oceanography Section Luncheon, scheduled for December 9, during the AGU Fall Meeting in San Francisco. Be sure to purchase your ticket early to ensure attendance. The luncheon speaker, Farris Webster, will talk on the "Research Outlook from NOAA."

U.S.-Soviet Team Explores Polynya

Satellite pictures in 1973 of the frozen Weddell Sea near Antarctica revealed an unfrozen "lake" surrounded by ice. In subsequent winters, the curiously unfrozen patch appeared, disappeared, reappeared, grew to nearly 300,000 km², and drifted westward before vanishing. The source and the effects of this unfrozen lake on its surroundings may remain a mystery for not much longer: A joint American-Soviet team recently began a 2-month, on-site investigation of the polynya (that's Russian for "unfrozen water surrounded by ice").

Two explanations for the polynya's existence predominate. One is that a strong wind blows ice away before a significant amount can accumulate, according to Arnold L. Gordon, *Eos* associate editor and professor of geological sciences at the Lamont-Doherty Geological Observatory. He is coordinating the expedition with the Arctic and Antarctic Research Institute in Leningrad. The other is that for some reason, enhanced convection is going on in this region. Basically, we think that the polynya is caused by upwelling of ocean water rather than ice being removed by high winds.

The surface waters surrounding Antarctica normally are frozen or almost so, Gordon explained, but at 200 m below the surface, the water's temperature is about 2°C. "Warm water rises to mix with colder surface water, but such convection isn't strong enough to melt the Antarctic ice." Such is the puzzle of the polynya.

More than being a quirk in the ice, the polynya may affect world climate and the distribution of nutrients in Antarctica's waters. "Because of the heat lost through the polynya, there is a major cooling of the abyssal ocean going on, which is important from a climatic point of view," Gordon said. "Much of the water below 1,000 m in the world's

oceans are derived from the Antarctic." In addition, the polynya may also affect organisms in the food chain, such as the tiny, shrimp-like krill that are found in abundance in the Antarctic waters.

Satellites have not yet revealed a polynya this austral winter, but a slight decrease in ice concentration has been inferred from satellite observations near 66° South, 5° East. Scientists are hoping that this weakening of the ice cover will develop into a polynya. "If none does appear this austral winter, we will study environmental conditions within the ice pack. Such a study has never been done before near the period of maximum extent," Gordon said. For example, the American-Soviet research team will study the thickness of the snow cover and the structure of the ice in an attempt to determine how the ocean is giving up heat to the atmosphere. The chemistry and biology of the prospective polynya and the surrounding area also will be studied.

Of the expedition's 28 scientists aboard the 137-M Soviet icebreaker *Mikhail Somov*, 13 are from the Soviet Union. The American team includes nine Columbia University scientists and four others from Oregon State University and the U.S. Army Cold Regions Research and Engineering Laboratory in Hanover, N.H.

OTA: Shore Up Federal Ocean Programs

Although the federal ocean effort consists of about 90 programs, at a cost of \$2.52 billion in fiscal 1980, there is no comprehensive plan or coordination for the development of new technologies to advance the programs, according to a report by an Office of Technology Assessment (OTA) panel. Federally supported technologies include ships, satellites for oceanography research, buoys, underwater vehicles, and independent instrument systems. To shore up the development of ocean technology, Congressional initiatives may be necessary, concludes the Technology and Oceanography Assessment Advisory Panel.

There is no consensus, the panel charged, among agencies in their plans for future program or capital expenditures. Furthermore, some agencies plan for possible future technology needs, while others do not plan for new expenditures until new items become vital. And, some programs plan include substantial contingencies and related activities, while others do not.

The 90 federal ocean programs are conducted primarily by eight agencies: the U.S. Coast Guard of the Department of Transportation, the Department of the Interior, the Environmental Protection Agency, the National Aeronautics and Space Administration, the National Oceanic and Atmospheric Administration, the National Science Foundation, and the U.S. Navy in the Department of Defense. Three of these agencies—the U.S. Coast Guard, NOAA, and the U.S. Navy—accounted for 80% of FY 1980 expenditures.

To rectify the problems, Congress could establish a central office to support future ocean technology development, according to the panel report. Specific technology development needs not being met by established offices also could be evaluated by Congress. Finally, Congress could establish an interagency ocean engineering strategy group to coordinate research.

In its report, "Technology and Oceanography: An Assessment of Federal Technology for Oceanography Research and Monitoring," the panel identified issues in four main areas concerning federal activities: ocean technology development, oceanic data systems, ships, and satellite oceanography.

Key to the issue of ocean technology development is whether a larger and more centralized ocean engineering effort within one or more federal agencies would significantly improve the future development of ocean technology. Proposals for a centralized organization have long been opposed. Many researchers worry that one central agency would not give individual programs the attention they deserve and would not allow the flexibility that programs require for budgeting, engineering priorities, or for the support of smaller programs. OTA recognizes the drawbacks of a centralized organization: "There is no way to centralize technology development adequately," states the report summary. "To meet the individual needs of every program and agency. Direct communications between the programs needing technology and the developers of technology is most important. . . and of utmost concern is assuring the availability of highly qualified personnel in each department or agency for critical program assessment and for focusing on promising directions in technology development."

Can the growing need to handle and distribute increasingly large volumes of oceanic data to a variety of users be met effectively within existing agencies? "Federal programs have not given adequate attention to the handling and distribution of oceanographic data," the panel maintains. Two steps need to be taken so that oceanic data will serve the growing user needs. First, OTA recommends, assign agency or program responsibility for comprehensive management geared to user needs. Then, choose a federal, regional, or private data management system and update it with modern technology. "Congress could initiate the first step by requiring that data management for all end-users be included in plans and budgets for major new programs."

OTA warned that the capabilities of the federal oceanographic fleet will continue to degrade without new funds or more efficient arrangements that will reduce costs. To establish and fund an interagency ship planning council. Such a council could have the authority to specify management and planning in an effort to reduce costs.

"Satellite remote sensing could become the lastest growing segment of oceanography if certain agency plans are followed," OTA stated; they evaluated whether the benefits of this costly technology warrant the costs. Satellite technologies could aid in the routing of ships, search and rescue operations, and gather immense amounts of data in a fraction of the time required by other methods. However,

"The extent to which satellites themselves will add new knowledge and thus justify very large costs is difficult to evaluate until more experience is obtained," OTA claimed. The panel report was prepared at the request of the Senate Committee on Commerce, Science, and Transportation. D. James Baker, Jr., of the University of Washington, chaired the review panel.—BTR

Meetings

Call for Papers

The 45th Annual Meeting of the American Society of Limnology and Oceanography will be held June 14-17, 1982, at North Carolina State University, Raleigh, N.C. At the Raleigh meeting, two special symposia are being organized: "South Atlantic Bight Processes," chaired by David W. Menzel and Thomas B. Curtin; and "Biological Effects of Inorganic Turbidity in Lakes," chaired by Samuel Mozley and John M. Miller. Daniel Kamykowski, Department of Marine Science and Engineering, is chairman of the local committee.

ASLO meetings are arranged into no more than four concurrent sessions of contributed papers during the 4-day period. Additional papers are presented as part of daily poster sessions.

The call for papers for the Raleigh meeting has been issued with deadline for receipt of abstracts being January 15, 1982. Because of the large number of abstracts that are submitted, it is the society policy only to accept abstracts from ASLO members.

ASLO currently has nearly 4,000 members. The officers are Richard Eppley, Scripps Institution of Oceanography, president; David Schindler, Freshwater Institute, vice president; Claire Schelske, University of Michigan, secretary; and Sumner Richman, Lawrence College, treasurer. Information about membership and membership application forms can be obtained from Mrs. Winifred Baumalter, Business Manager, ASLO, 1530 12th Avenue, Grailon, WI 53024.

The society publishes one journal, *Limnology and Oceanography*. The journal editor is Yvette Edmondson, University of Washington.

New Publications

Remote Sensing of Atmospheres and Oceans

A. Deepak (Ed.), Academic, New York, xiv + 841 pp., 1980, \$45.00.

Reviewed by Conway B. Leovy

The second conference on Remote Sensing of Atmospheres and Oceans was convened in May 1979 at Williamsburg, Va., under the auspices of the Institute for Atmospheric Optics and Remote Sensing and the Office of Naval Research. The papers presented at the conference are reproduced in this volume. Like the first such conference, in 1978, these proceedings provide a good picture of most of the major problems in the field at the time, and, like most such state of the art research collections, it can be expected to have a fairly short useful half-life. For those actively involved in either remote sensing research, or the use of the meteorological data gathered by remote sensing techniques, this volume will be of considerable value, however. On the whole, the papers are well written and most are presented in such a way that the important ideas can be readily appreciated by nonspecialists. The usefulness of the book is enhanced by inclusion of the discussion accom-

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panying each presentation that serves the dual purpose of alerting the reader to underlying areas of concern in the research area and, in some cases, of clarifying just those points that will be obscure to many readers.

Some 25 papers are included under the broad headings of "Recent Advances in Inversion Methods," "Remote Sensing of Atmospheric Parameters" (with subheadings of "Temperature," "Aerosols," "Gaseous Constituents," and "Microwaves"), "Remote Sensing of Winds," "Remote Sensing of Ocean Parameters," and "Interpretation of Recent Results From Space" (this last being something of a catch-all, including results from new earth-viewing instruments as well as from other planets). It is impossible here to detail all of the papers, but perhaps a few highlights will indicate the flavor. Under the first heading, P. M. Tollefson shows how the Kalman filter technique can be combined with the output of a general circulation model to provide a highly adaptive solution to the problem of assimilating a global set of remote sensing data. J. Suskind and A. Rosenfeld and E. W. Koehn then present two interesting papers on the (1979) state of the art TIROS-N system, Suskind and Rosenfeld on retrievals of a large number of soundings in the presence of variable cloud cover, and Koehn on the TIROS NIRS/2 instrument and its performance in orbit. Three papers discuss the interpretation of optical measurements in terms of aerosol size distributions (A. Deepak, M. A. Box, and G. P. Box), volatility (P. Hamill, T. J. Swisher, M. Osborn, and M. P. McCormick), and detailed vertical structure (T. J. Papin). A paper by S. L. Taylor, P. U. Bharila, V. G. Kaveashvili, K. F. Klenk, A. J. Fiebig, and C. L. Mader on ozone retrieval using backscattered ultraviolet radiation shows that reasonably accurate retrievals should be feasible down to 30 mbar or so if multiple scattering is properly accounted for.

Two important themes deal with the status of passive microwave sounding and the sensing of ocean surface parameters. N. C. Grody discusses retrieval of temperatures and geostrophic winds with the three-channel TIROS-N MSU (Microwave Sounding Unit), and shows the improvement that would be expected with a five-channel microwave sounder. D. H. Staelin discusses four microwave retrieval problems characterized by increasing nonlinearity, Doppler wind measurements, retrieval of water vapor profiles, retrieval of snow accumulation rate, and classification

of diverse ice-covered polar terrains, while P. W. Rosenkranz and W. T. Bauman present a detailed discussion with illustrative examples of the use of the 10 pieces of information (five channels and two polarizations) of the SEASAT and Nimbus 7 Scanning Multi-Channel Microwave Radiometer (SMMR). Rosenkranz and Bauman show how accuracy and resolution can be traded off in the retrieval, over oceans, of surface temperature, wind speed, water vapor, cloud and precipitation liquid water, and water vapor scale height.

The resiliant problem of retrieving sea-surface temperature is discussed in papers by M. T. Chahine, L. M. McMillan, D. S. Crosby, and J. E. DePietri, and H. E. Fleming who describe the use of the split window technique in the infrared and of truncated normal radiance distributions to remove cloud effects. It now appears that the goal of achieving global sea-surface temperature distributions with accuracies of 1°C at resolutions of a few tens of kilometers from satellite radiance alone is within reach. A theoretical paper by P. Y. Deschamps, M. Herman, J. Lenoble, D. Tanre, and M. Viollier and an applied paper by H. R. Gordon, J. L. Mueller, and R. C. Wrigley deal with the problem of removal of atmospheric aerosol effects in visible and near infrared wavelength images in order to map distributions of marine phytoplankton. Application of the technique of Gordon et al. to images from the Nimbus 7 CZCS (Coastal Zone Color Scanner) yields very encouraging results.

Additional interesting papers deal with the design and application of a ground-based remote sensing system (D. C. Hogg, F. O. Guitard, C. G. Little, R. G. Strauch, M. T. Descker, and E. R. Westwater), retrieval of stratospheric minor constituents from Nimbus 7 limb scanning measurements (papers by L. L. Gordley and J. M. Russell and by C. D. Rodgers), and on the thermal structure of Jupiter's atmosphere (B. J. Conrath and D. Gautier). Nobility absent from the conference was W. L. Smith, and no papers deal with the important area of his recent interest, the interpretation of satellite data in terms of mesoscale phenomena.

Conway B. Leovy is with the Department of Atmospheric Sciences, University of Washington, Seattle, Washington.

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Petrologist-Economic Mineralogist/University of Oklahoma. Applications are invited for a tenure-track position, effective September 1, 1982. The successful applicant will be responsible for teaching graduate courses in petrology and mineralogy, and to pursue an active research program. Consulting and interacting with other departments are encouraged.

The University of Oklahoma has made a major commitment to diversify the program in the School of Geology & Geophysics. As a result five tenure-track positions are open for the fall of 1982. Six 1981 (beginning the total full-time faculty to 15), and 1982-1985. A new building that will house the School in the design stage, and the successful applicant will participate in supplying it.

The Ph.D. degree is required for this position. The successful applicant will be given to petrology with a strong background in the economic geology of metallic and non-metallic mineral deposits. Qualified applicants should arrange to send transcripts of all college and university work, resumes, statement of research interests, and three letters of reference to: Dr. Mayfield Cameron, School of Geology and Geophysics, University of Oklahoma, Norman, Oklahoma 73019. Deadline for applications is December 31, 1981. Faculty members from the School will be interviewing at the November 6-8, A.G.U. meeting in San Francisco, California. The University of Oklahoma does not discriminate on the basis of race, sex, and is an equal opportunity employer.

Virginia Polytechnic Institute and State University: Senior Research Associate. Interesting and abundant research and publishing opportunities, including new University-owned MOS-10 VIBROSEIS system, VAX 11/780 computer. Must have experience in theory and application of reflection seismology, and be interested in the application of reflection seismology to the solution of geologic problems.

Send resumes to: Dr. O. R. Wines, Department of Geological Sciences, Virginia Polytechnic Institute and State University, Blacksburg, VA 24031-0788.

The University is an equal opportunity/affirmative action employer.

Iowa State University of Science and Technology/Department of Earth Sciences.

Applications are invited for two tenure track faculty positions. The rank for each is at the assistant or associate professor level, dependent upon qualifications. The successful applicant will be expected to develop along research and graduate student programs. Teaching duties will include undergraduate and graduate courses in the areas of:

Mineral Resources/Economic Geology: One position is in mineral resources/economic geology. An applied field orientation is preferred. Iowa State has established a Mining and Mineral Resources Research Institute and an interdisciplinary minor in Mineral Resources in order to support and develop research and education in this area. In addition to the appointment in the Department of Earth Sciences there will be full opportunities to interact with these programs.

Geomorphology: The second position is in the general field of geomorphology. Additional expertise in an area related to geomorphology, such as groundwater, engineering geology or remote sensing is also desired. A person with an applied field orientation is being sought.

Each appointment will be on an academic year basis. Opportunities are available for summer teaching appointments. Salaries will be commensurate with qualifications. Application deadlines for both positions are February 15, 1982; later applications will be accepted if a position is not filled. Positions are both currently available and are expected to be filled no later than fall, 1982. For application information please write to:

Barl E. Nordlie
Department of Earth Sciences
253 Science I
Iowa State University
Ames, Iowa 50011
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Staff Scientists/Scientific Programmers. Research & Data Systems, Inc. has openings available for Staff Scientists and Scientific Programmers to work in areas involved in the processing and application of data from satellite based remote sensing systems. Particular needs involve the study of atmospheric dynamics specifically as it relates to the atmosphere/thermosphere interface, atmospheric composition and dynamics and dynamic feedback mechanisms. Other needs exist in the areas of satellite data processing, objective analysis and radiative transfer. Successful candidates will have an advanced degree in meteorology, physics, astronomy or mathematics with a strong computer software background particularly in IBM equipment. Send resumes in confidence to: Research & Data Systems, Inc., 9420 Annapolis Road, Lanham, Maryland 20706. Telephone: (301) 469-0001.

University of Hawaii Faculty Positions. The Department of Geology and Geophysics and the Hawaii Institute of Geophysics of the University of Hawaii are seeking applicants for two tenure track positions becoming available January 1, 1982. Applicants should have specialization in (1) marine geophysics with emphasis in one or more of the fields: marine seismology, magnetism and gravity; or (2) marine geology sedimentology. One of these positions will be filled at a rank of full professor, the other at assistant or associate level.

Applicants should have demonstrated ability to conduct and promote marine research commensurate with the level of the appointment. Ability to teach at all levels is expected. The positions will be joint ones on an 11-month basis with the Department and the Institute and will involve both teaching and research responsibilities. Apply with resume, expected level of appointment and the names of 3 referees to: Chairman, Personnel Committee, Department of Geology and Geophysics, University of Hawaii, Honolulu, Hawaii 96822.

Closing date for applications is January 1, 1982. The University of Hawaii is an affirmative-action/equal opportunity employer.

Groundwater Hydrologist. The Minnesota Department of Natural Resources, Division of Waters has a vacancy at the Principal Hydrologist level for an experienced groundwater hydrologist to provide leadership for a program of ground water studies and monitoring to support State Water allocation decisions and to provide quantitative assessment for planning and management purposes. The successful applicant will be expected to participate in both the undergraduate teaching and graduate studies programs, as well as actively engage in research. Rank and salary are open but will be commensurate with qualifications.

Purdue University is a land grant, state supported institution committed to academic excellence, and is an equal opportunity/equal access employer. For further information please contact Dr. Henry O. A. Meyer, Dept. of Geosciences, Purdue University, West Lafayette, IN 47907 (Tel. 317-484-3271). Closing dates for applications is November 10, 1981.

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Sedimentologist/University of Utah. Search extended: The University of Utah is expanding its geophysics program in the Department of Geology and Geophysics by adding a tenure track faculty member in sedimentology to the assistant to associate professor level. Applicants with backgrounds and specialties in sedimentology, seismic mapping, and theoretical sedimentology will be given preference. The individual will be expected to teach undergraduate and graduate courses, and to pursue an active research program with graduate students. The department has modern teaching and research programs in geology and geophysics, and has close associations with the numerical analysis and data processing groups in computer science, electrical engineering and mathematics. The geophysics component of the department has strong research and teaching programs in sedimentology, electrical and electromagnetic methods, thermal properties of the earth, and potential fields. Current research in sedimentology includes: sedimentology and earthquake research utilizing a new POP 1170 computer with plotter and terminal; monitoring of the Intermountain seismic belt by a 55 station teleseismic network utilizing a new on-line POP 1170 computer; major experiments in seismic reflection geology; investigations of seismic propagation from synthetic seismograms; application of inverse theory to sedimentology; seismic properties of volcanic systems and allied research in volcanophysics. The closing date for applications is December 31, 1981. A Ph.D. is required for this position. Applicants should submit a vita, transcripts, a letter describing his/her research and teaching goals, and names of five persons for reference to William P. Nash, Chairman, Department of Geology and Geophysics, University of Utah, Salt Lake City, Utah 84112.

The University of Utah is an equal opportunity affirmative action employer.

Structural Geologist/University of Wyoming. The University of Wyoming, Department of Geology and Geophysics seeks applicants for a tenure track appointment in structural geology. The position is available beginning fall semester 1982 or earlier. Duties will include teaching of undergraduate and graduate courses in structural geology, supervising MS and PhD theses, and research in structural geology. Appointment as assistant professor level is preferred, but applicants requesting appointment at higher rank will be considered. Salary open. Applicants must have PhD degree and be versed in quantitative theory as well as solid applications or modern structural geology and regional tectonics.

Applicants should provide, by January 1, 1982, a resume, three letters of reference, and a letter of application including a statement of current research interests and courses which the applicant feels qualified to teach. Applications should be sent to:

Dr. Robert S. Houston Head
Department of Geology and Geophysics
University of Wyoming
Laramie, Wyoming 82071-3009
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Engineering Geologist/Geophysicist. The Department of Geological Sciences, University of Saskatchewan, has a vacant tenure position in engineering geology/geophysics. Applicants should be qualified to teach undergraduate and graduate courses and to conduct research in engineering geology. A background in structural geology may be appropriate. Well-equipped facilities are available for research in rock mechanics, fluid flow through porous media, acoustic, and electrical properties of rocks, and permeability. Good opportunities exist for joint research with qualifications and experience. Send applications, detailed personal resume including the names of at least three referees, and other supporting data to Dr. W.G.E. Caldwell, Head, Department of Geological Sciences, University of Saskatchewan, Saskatoon, Saskatchewan, S7N 0W0.

Please note: until November 15, 1981 consideration will be given only to applicants who are Canadian or landed immigrants, after that date all applications will be considered.

Visitor Appointment: NCAR. Visitor Appointments of the High Altitude Observatory are available for new and established Ph.D.'s for up to one year periods to carry out research in solar physics, solar-terrestrial physics, and related subjects. Applicants should provide a curriculum vitae including education, work experience, publications, the names of three scientists familiar with their work and a statement of their research plans. Applications must be received by 15 January 1982, and they should be sent to: Visitor Committee, High Altitude Observatory, National Center for Atmospheric Research (NCAR), P.O. Box 3000, Boulder, Colorado 80507. NCAR is an equal opportunity affirmative action employer.

University of Utah Faculty Positions. The Department of Geology and Geophysics invites applications for four tenure track positions at the assistant to associate professor level.

- 1) **Economic Geology.** The specific area of expertise is open, however, preference will be given to candidates whose research interests are in geology, geochemistry, or petrology of characteristics of metallic mineral deposits.
- 2) **Sedimentary geology.** Applicants should have research interests in modern or ancient sedimentary basins.
- 3) **Sedimentology.** Applicants with backgrounds and specialties in seismic reflection, seismic imaging or theoretical sedimentology will be given preference.
- 4) **Potential fields.** Geophysicist with expertise in potential field including gravity and magnetism. (The closing date for this position is January 31, 1982).

A Ph.D. or equivalent is required. The vacancies are to be filled by September 1982; the closing date for applications for positions 1-3 is December 31, 1981. Applicants should submit a vita, transcripts, a letter describing his/her research teaching goals, and names of five persons for reference to William P. Nash, Chairman, Department of Geology and Geophysics, University of Utah, Salt Lake City, Utah 84112.

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Faculty Positions. Two Faculty Positions in Geology. Tenure-track positions in geology, assistant professorships. Ph.D. preferred or equivalent experience. Fall 1982.

Petrologist-Mineralogist. Candidate must be able to teach introductory geology, mineralogy, petrology, geochemistry, and optical mineralogy. Involvement in Paleontological-Salt-Rock Geologist. Candidates must be able to teach courses in invertebrate paleontology, micropaleontology, sedimentology, and historical geology. Additional expertise in recent marine environments highly desirable.

Applicants are expected to do research in their areas of expertise, and to lead students' field trips. Strong teaching and research commitments expected. Submit applications with resume and copies of transcripts, and have three letters of recommendation sent to the Chairperson, Department of Earth & Space Sciences, Indiana University-Purdue University at Fort Wayne, Fort Wayne, Indiana 46805.

Indiana University-Purdue University is an equal opportunity affirmative action employer.

Position in Reflection Seismology/Rice University, Houston, Texas. The Department of Geology plans to expand its geophysical program. Emphasis will be on reflection seismology. At this time applications are for the position of open faculty positions. The successful applicant will help in the search for and selection of the second faculty member.

Your main responsibility will be to lead our department into the area of modern reflection seismology. Your main teaching and research interests should be in the acquisition and processing of reflection seismic data. You should also help in developing rigorous undergraduate and graduate curricula, which are supported by the traditional strength of the Math Sciences, Physics, and Electrical Engineering Departments at Rice. Enthusiasm to work with and undertake some joint projects with our geologists is essential.

Our plans are to acquire a computer system configured for high quality data processing. Substantial seed money for this facility is already in hand. Creative cooperation with the oil and geophysical industry in Houston, including a reasonable amount of consulting, is encouraged. Salary will be commensurate with qualifications and experience. Please send your curriculum vitae, a summary of experience in seismic processing, a statement of research interests, and names of three or more references to Dr. A. W. Bally, Chairperson, Department of Geology, Rice University, P.O. Box 1922, Houston, Texas 77001. Application deadline—October 1, 1981.

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Stanford University. A postdoctoral or research associate appointment is available in the area of space plasma physics. Topics of study include data from electron beam experiments about the space shuttle and the behavior of low energy plasma in the magnetosphere. Resumes and names of three references should be sent to Professor P. M. Banks, Radio Science Laboratory, Department of Electrical Engineering, Stanford University, Stanford, CA 94305.

Stanford University is an equal opportunity affirmative action employer.

Faculty Position in Watershed Hydrology. The School of Forestry and Environmental Studies at Duke University invites applications for both tenure-track and research appointments in watershed hydrology. Joint appointment with other university departments is possible.

Applicants should have background in physical and biological processes important in watershed hydrology, impact of land use on water quantity and quality, and quantitative methods including statistics, systems analysis, simulation. Requires Ph.D. with one degree in a natural resource area.

Write for position announcement or submit curriculum vitae, representative publications, three references by December 15 to: Chairman, Faculty Council, School of Forestry and Environmental Studies Box EA, Duke University, Durham, NC 27708.

Duke University is an equal opportunity affirmative action employer.

University of North Carolina at Charlotte/Faculty Positions in Earth Sciences. The Department of Geography and Earth Sciences offers an interdisciplinary major in Earth Science, which includes a geology track and a developing focus on water resources. The department is seeking to fill two tenure-track faculty positions at the Assistant Professor level to begin August 1982:

- (1) Geologist with specialties in mineralogy, petrology and possibly structural geology. Must also teach introductory geology and have a field orientation.
 - (2) Earth Scientist with primary interests in climatology and soils along with shared responsibility for teaching introductory Earth Science courses and possibly meteorology.
- All candidates for tenure track appointments must have a Ph.D. and other with substantial doctoral coursework and experience will be considered for lecturer appointments.
- Send a letter explaining your interest in either position, along with a current vitae, to Alfred W. Stuart, Chairman, Department of Geography and Earth Sciences, UNCC Station, Charlotte, NC 28223. Phone: 704-587-2293.
- Closing date for initial application is January 1, 1982.

AAEO employer

Graduate Research Assistantships in Physical Oceanography and Meteorology. The Division of Meteorology and Physical Oceanography, School of Marine and Atmospheric Science, University of Miami, invites applications from students in science or engineering with a strong background in physics and mathematics and an interest in either the atmosphere, the ocean, or the air-sea interface. Remuneration includes a yearly stipend of \$7,150 plus the cost of tuition (\$4,160, first year). Successful applicants will pursue either a M.S. or Ph.D. involving work in a wide range of observational/experimental or theoretical research. For details and/or application write: Dr. Friedrich Schott, Division of Meteorology and Physical Oceanography, School of Marine and Atmospheric Science, University of Miami, 4800 Rickenbacker Causeway, Miami, Florida 33146.

Vincent C. Kelley and Leon T. Silver Graduate Fellowships DEPARTMENT OF GEOLOGY THE UNIVERSITY OF NEW MEXICO

The Department of Geology of the University of New Mexico invites applications for the Vincent C. Kelley and Leon T. Silver Graduate Fellowships. The fellowships will be awarded on the basis of the scholastic record and academic promise of graduate applicants. Each fellowship will provide for a generous living stipend of \$1,000/month for 9 to 12 months, and up to \$2,000/year for travel and research expenses. The Caswell Silver Foundation will pay all tuition and university fees. The awards are made on an annual basis, but may be renewed for up to three years as long as the student maintains excellent academic standing and shows evidence of excellent progress in research. Preference will be given to, but not restricted to, applicants for the Ph.D. program.

An application for admission to the UNM Graduate Program, transcript, Graduate Record Exam results (verbal, math & geology), three letters of reference and a brief statement of research goals are required for consideration for the fellowships. Application materials may be obtained from:

Rodney C. Ewing
Chairman
Department of Geology
University of New Mexico
Albuquerque, New Mexico 87131



The deadline for applications is March 1, 1982 for the Fall semester of 1982.

University of Leeds/Geologist. Applications are invited for a post of Postdoctoral RESEARCH FELLOW in the Department of Earth Sciences for a fixed term of up to two years. The research programme of the Geology Group in the Department includes geochronology oriented particularly towards evolution of metamorphic belts, and applications of radiogenic isotope geochemistry to petrogenetic problems and the present state of knowledge of the earth's mantle. Equipment available includes two solid-source mass spectrometers (Micromass 30 and Isomass 64) for Sm-Nd, U-Pb, Rb-Sr and REE determinations and two MS10's for K-Ar and ⁴⁰Ar/³⁹Ar with supporting chemical facilities which are dedicated to these programs and to projects in oceanic isotope geochemistry. The successful applicant will be expected to initiate work in one or more of these fields and to collaborate in appropriate current projects. Salary within the range £2070-£10160 according to age, qualifications and experience. Informal enquiries may be made to Professor J. C. Eldon. Further particulars and application forms (of desired) may be obtained from the Registrar, The University, Leeds LS2 9JT, UK, quoting reference number 1981/1. Closing date for applications 30 November 1981.

SENIOR Physical Oceanographer \$A24,951-\$A33,616 pa CSIRO Marine Laboratories Division of Oceanography Sydney NSW, Australia

GENERAL: CSIRO has a broad charter for research into primary and secondary industry areas. The Organization has approximately 7,400 employees—2,700 of whom are research and professional scientists—located in Divisions and Sections throughout Australia. In March 1981, the CSIRO Division of Fisheries Research and a Division of Oceanography. These Divisions collectively form the CSIRO Marine Laboratories, and are Australia's principal marine laboratories, employing about 200 scientists and support staff. The main laboratory is in Sydney and there are smaller laboratories in Brisbane and Perth.

Depending on Parliamentary approval, the Sydney activities will be transferred to new laboratories to be constructed on a deep waterfront site in Hobart, Tasmania. The appointee must be prepared to transfer to Hobart at any time after December 1982. The Australian Government has also agreed to the acquisition by CSIRO of a modern oceanographic ship to replace the presently chartered 'Sprightly'.

The interests of the Division in physical oceanography include continental shelf dynamics, mixed layer and upwelling dynamics, air-sea interaction, ocean circulation and boundary currents, the interpretation and application of satellite data, numerical modelling and geophysical fluid dynamics.

DUTIES: The appointee will take a leading role in the initiation and conduct of research within these fields and in relation to existing or future programs. On occasions, the appointee may be expected to participate in or to lead research vessel cruises.

QUALIFICATIONS: A PhD or equivalent qualification in physical oceanography, geophysical fluid dynamics or some other relevant discipline, and several years of experience and substantial research achievement.

TENURE: Indefinite with superannuation.

APPLICATIONS: In writing, quoting reference number A2425, giving full personal particulars including details of qualifications and experience, copy of academic transcript and the names of at least two professional referees should reach:

The Chair
Division of Oceanography
CSIRO
PO Box 21
CHRONULA NSW 2230
AUSTRALIA
Deadline: November 13, 1981.

CSIRO

Scientists/Meteorologists/Engineers. Scientists/Meteorologists/Engineers, (SSAI) has positions for programming, analysis, scientists and engineers to engage in Scientific Modeling and Analysis activities in the areas of:

1. PLASMA/IONOSPHERIC PHYSICS THEORETICAL SIMULATIONS
2. ATMOSPHERIC/OCEANIC SCIENCES
3. REMOTE SENSING & RADIATIVE TRANSFER/SCATTERING STUDIES
4. SATELLITE DATA ANALYSIS
5. WEATHER/CLIMATE & SEVERE STORMS STUDIES
6. ATMOSPHERIC/FLUID DYNAMICS
7. SOLAR AND PLANETARY PHYSICS AND ASTRONOMY
8. COMPUTER IMAGE PROCESSING AND SYSTEMS DISPLAYS
9. SYSTEM SOFTWARE/HARDWARE ENGINEERING
10. NUCLEAR FISSION/FUSION
11. APPLIED MATHEMATICS

These positions involve working with NASA/NOAA/AFSC/USAF scientists in metropolitan Washington, DC area.

Among background in numerical simulations, and experience in working with large scale computers is required for entry level to senior scientist/engineer positions. SSAI provides a congenial academic environment, pays liberal fringe benefits and awards bonuses to its employees with salary history and years of service.

Peaks send your resume with salary history and years of service to: SCIENCE SYSTEMS AND APPLICATIONS INC., The Aerospace Building, 10210 Gumbel Road, Suite 140, Seabrook, MD 20706.

Assistant Professor/Department of Geology, University of Vermont. The Geology Department at the University of Vermont is recruiting to fill a tenure track position at the assistant professor level to begin September 1982. Field of specialization should complement existing faculty expertise in geology, structure and regional geology. Applicants are solicited in, but not restricted to, geophysics, geochronology, paleogeography, hydrology, paleontology or economic geology. The successful candidate will be expected to develop a research

program involving both graduate students (M.S.) and advanced undergraduates. Applications will be accepted until December 1981.

Candidates should send resume and arrange for three letters of reference to be sent to:

Dr. John C. Orin
Acting Chairman
Department of Geology
University of Vermont
Burlington, VT 05405

The University of Vermont is an equal opportunity affirmative action employer.

Assistant/Associate Full Research Professor. Conserve and carry out original research projects in field of physical oceanography. All areas of research will be considered, but some preference will be given to applicants interested in numerical modeling, coastal zone dynamics, physics and dynamics of fronts, multi-dimensional, mesoscale and large scale ocean circulation or air-sea interaction. Development of own research program expected. Excellent opportunities for interacting with ongoing Gulf Stream projects, Solar field group, and new remote sensing center. Send resume and statement of research by April 1, 1982 to: Employment Relations Office, Floor E-0000, Personnel Office, UNIVERSITY OF RHODE ISLAND, 60 Lawrence College Road, Kingston, RI 02881.

An affirmative action/equal opportunity employer.

Assistant/Associate Professor Marine Affairs. Tenure track beginning Fall 1982. Teach graduate/undergraduate courses in marine science/technology policy, marine technology, and introductory oceanography in a successful interdisciplinary department. Scholarly research, participation in student development and departmental administration. PhD in a marine science and appropriate relevant experience. Send resume and 3 letters of recommendation by 2/15/82 to: Employee Relations Office, Personnel Office E-020005, UNIVERSITY OF RHODE ISLAND, Kingston, Rhode Island 02881.

An affirmative action/equal opportunity employer.

University of California, Davis Ignouss Petrologist. The Department of Geology invites applications for a tenure-track position in the field of igneous petrology, at the Assistant Professor level, effective for the academic year 1982-1983. Preference will be given to candidates whose research demonstrates a thorough understanding of field, theoretical and experimental approaches to the science and who show promise for high caliber research on fundamental problems. The successful candidate will be expected to contribute effectively to the existing teaching program in igneous petrology at both the undergraduate and graduate levels.

Departmental facilities include a thin-section laboratory, electron microprobe, both of which are supported by full-time personnel, an experimental laboratory with high pressure piston cylinder and low pressure externally heated equipment, a scanning electron microscope, stable isotope laboratory, as well as the usual equipment (XRF, XRD, computers, etc.). The University of California at Davis is located conveniently to areas containing all types of igneous rocks.

The final date for receipt of applications is February 1, 1982. The University of California is an equal opportunity affirmative action employer.

Interested individuals should send their resume to:

Jens H. Lipka, Chair
Department of Geology
University of California
Davis, California 95616

Yale University/Department of Geology and Geophysics. Applications are solicited for a faculty position in solid state geophysics to begin in the academic year 1982-83. Areas of interest to the Department include sedimentology, exploration geophysics, mechanical and physical properties of rocks and minerals, geomagnetism, and tectonophysics.

Yale University is an equal opportunity affirmative action employer and encourages women and members of minority groups to compete for this position. Curriculum vitae, publications and the names of three or more referees should be sent by 31 October.

ember 1981 to Robert B. Gordon, Chairman, Department of Geology and Geophysics, P.O. Box 8666, New Haven, CT 06511.

SERVICES

PETROLEUM DEPOSITS. If you are financing, planning, designing, exploring, drilling, or digging in connection with any form of energy, you need this complete, up-to-date book about the world's petroleum deposits. Includes production and reserves for areas. Hardcover, 6 x 8 inches, 376 pages. Table of contents, drawings, index, references, 1974.

\$50. Tecton Associates, 120 Thunder Road, Sudbury, MA 01776

STUDENT OPPORTUNITIES

Graduate Research Assistantships in Physical Oceanography. Opportunities for graduate study with Research assistantship available for students interested in M.S. or Ph.D. programs. A summer program with stipend is open to college juniors. Write: Douglas Caldwell, School of Oceanography, Oregon State University, Corvallis, OR 97331

Graduate Teaching & Research Assistantships/University of Houston. Graduate teaching & research assistantships available to qualified persons interested in Space Physics at the University of Houston. Our experimental program features rocket & balloon-borne studies of the ionosphere & magnetosphere-ionosphere coupling. Emphasis has been on active experiments, most recent from rocket-balloon campaign of Siple Station, Antarctica in October 1980. Future work includes a study of pulsating aurora & participation in Weterholt II, an auroral quenching experiment. The theoretical program is on plasma waves in the solar wind & modeling of phenomena related to current experiments. Assistantships for first year students range from \$600 to \$800 with out of state tuition. Graduate Chairmen, Physics Dept., University of Houston Central Campus, Houston, TX 77004 EOE

Scholarship Assistance for Minority Students in Earth, Space, and Marine Science For 1982-1983

The American Geophysical Union once again pleased to participate in the American Geological Institute's Minority Scholarship Assistance Program.

Eligible Candidates are:

- Graduate or undergraduate students with good academic records
- Enrolled in, or applying to, an accredited institution to study earth, space, or marine science
- Black American Indian, or Hispanic students who are U.S. citizens

For a flyer for your student, call or write to:
Member Programs & American Geophysical Union • 2000 Florida Ave., N.W. • Washington, D.C. • 20004 • 462-6913 or 800-424-2488 outside the Washington, D.C. area

For applications, write to:
William H. Matthews III, Director of Education • American Geological Institute • Box 10031, Lamar University Station • Beaumont, Texas • 77710

Application Deadline, February 1, 1982

Meetings

Solar-Terrestrial Physics Symposium

The Fifth International Symposium on Solar-Terrestrial Physics will be held in Ottawa, Canada, on May 17-22, 1982, the week before the 1982 COSPAR (Committee on Space Research) meeting. Deadline for abstracts for the solar-terrestrial physics meeting is December 31.

A commemoration of the anniversaries of the International Polar Year, the International Geophysical Year, and the beginning of the space era is planned. The 18 scientific sessions that highlight the meeting are divided into 4 categories: sun, interplanetary medium, magnetosphere and ionosphere, and middle atmosphere/thermosphere. Physical interpretations and theory will be emphasized; discussion of data and instrumental techniques will be discouraged.

In addition, eight tutorial lectures will address scientific problems of current interest. The symposium will conclude with five general reviews on human interactions with the solar-terrestrial environment and a public forum on long-range plans for research in solar-terrestrial physics.

Send abstracts and requests for additional information to: Alan G. Reeder, chairman of the program committee, Geophysical Institute, University of Alaska, Fairbanks, AK 99701 (telephone: 907-479-7282). Only one paper per author will be accepted because of time limitation during the symposium.

The symposium is organized by the Scientific Committee on Solar-Terrestrial Physics (SCSTEP) with the cosponsorship of COSPAR, the International Association of Geomagnetism and Aeronomy (IAGA), the International Union of Radio Science (URSI), and the International Union of Pure and Applied Physics (IUPAP). \$

NASA Geodynamics Conference

The Fourth Annual Conference on the NASA Geodynamics Program has been scheduled for January 26-29, 1982, at the Goddard Space Flight Center in Greenbelt, Md.

Sponsored by NASA Headquarters, the conference will cover the use of space techniques to study crustal deformation, plate stability, polar motion, earth rotation, gravity and magnetic fields, and regional stress.

Abstracts of papers to be considered for presentation at the conference should be sent to Jim Murphy, Program Coordinator, NASA Headquarters, Washington, D.C. 20546, Attn: ERG-2; deadline is November 23. Abstract format is available from Murphy. The conference coordinator, Patrick Taylor, requests that all those who wish to participate in the conference notify him by December 11. Write to him at NASA/Goddard Space Flight Center, Code 922, Greenbelt, MD 20771 (telephone: 301-344-5554 or -5213). \$

Nominations for AGU Fellows and Awards

November 15 is the deadline for nominations from the membership for AGU Fellows and December 15 for awards for 1982. Nominations for Fellows must be made on forms available from the AGU office. Nominations for medals and awards require only a letter of nomination and supporting material. The Board of Directors, which makes the final decision, will meet in December 1982 at this time.

American Geophysical Union
2000 Florida Avenue, N.W.
Washington, D.C. 20009

GAP

Oceanography

THE STRONG FRONT: A COMPARISON BETWEEN FLUID AND SOLID STATE MODELS OF THE GULF STREAM. R. A. ROSENBLUTH, Department of Physics, University of Maryland, College Park, MD 20742.

In a recent paper by Cheney and Roth (1981) a solid state model was used to derive a quantitative prediction for the width of the Gulf Stream. The model was based on the assumption that the Gulf Stream is a solid state system. The model was compared with the fluid state model of the Gulf Stream. The model was found to be in good agreement with the fluid state model.

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a steady uniform wind, fluid is accelerated in the direction of the wind, and the sea surface elevation gradient builds up at constant rate. The wind stress is assumed to be proportional to the square of the wind speed. The wind stress is assumed to be proportional to the square of the wind speed. The wind stress is assumed to be proportional to the square of the wind speed.

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current was not seasonally steady. A least-squares analysis to which meter waves were assumed proportional to the square of the wind speed yielded a value for the wind stress of 1.2×10^{-3} dyne/cm². The wind stress is assumed to be proportional to the square of the wind speed. The wind stress is assumed to be proportional to the square of the wind speed.

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